VARIAN associates

INTEROFFICE

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To E. L. Ginzton **Date** January 7, 1960

Subject Propulsion by Ejection of Positive and Negative Ions of Equal e/m **From** Edward W. Herold

You showed me a proposal of Prof. J. Lederberg, dated March 23, 1959, in which he suggested use of certain compounds which, if dissociated into positive and negative ions, would have equal ratios of charge to mass. Thus, any acceleration or guidance method which depends on this ratio would act equally on both charges. You asked for comments, and suggested that Bill McBride consider the possibilities in this idea. Bill and I have talked this over, but we do not believe the idea is enough of an improvement, nor is it readily put into practice. My own comments are as follows.

The problem of space vehicle propulsion by ion injection is a most important one, and in my opinion will be solved in the next decade. However, many propulsion experts claim that the ion or plasma ejection is a simple and straightforward matter compared to the problem of a power supply, which is truly formidable. Although I believe that a plasma of positive ions and electrons is the simplest and best material to eject, one should always keep an open mind as to other possibilities.

Prof. Lederberg's proposal is interesting but incomplete since the major problem of how to get negative ions is not solved. It is well known that such ions are extremely scarce, and for very obvious reasons. If energy is added to a molecule, it always tends to lose an electron, i.e. to go in a direction of positive ionization. A negative ion, which requires an extra electron is fundamentally less likely and less stable. As a result little practical use can be made of negative ions, and the achievable currents are many orders of magnitude below those which would probably be needed for propulsion.

A second point which might be made is that the requirement for equal e/m, for both positive and negative particles, is not necessary. For example, there are acceleration methods which impart the same velocity, in the same direction, to positive and negative charged particles independently of their e/m (a crossed electric and magnetic field does this). Even if there is a vast difference between the e/m of the positive and the negative particles, space charge forces keep them together, and the plasma moves with an effective velocity depending on the geometric mean of the two masses. Thus, any acceleration of either particle results in acceleration of the oppositely-charged particle as well.

I am not sure I understand all of Prof. Lederberg's suggestions, particularly on use of compounds. For example, he proposes $GeCl_2$ but the normal stable compound of Ge and Cl is $GeCl_4$ and I'm not sure how one could get the former material. Furthermore, if one could get it, when it dissociates, it must go to doubly-ionized Ge, i.e. Ge^{++}, in order to balance the e/m of a negative-ion chlorine. The more likely compound, $GeCl_4$, does not fulfil his requirement at all, unless <u>two</u> electrons are <u>added</u> to the system. It is possible I have not correctly understood his proposal at all, but the comments in the two paragraphs above still apply.

I return Prof. Lederberg's letter and attachment herewith.

EWH

EWH:mb

E. W. Herold

cc: Bill McBride